STRUCTURE AND METHOD FOR A FAST RECOVERY RECTIFIER STRUCTURE

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to the provisional patent application, Ser. No. 60/754,550, entitled "Fast Recovery Rectifier Structure," filed Dec. 27, 2005, and assigned to the assignee of the present invention, which is herein incorporated by reference in its entirety.

This application is related to co-pending, commonly owned U.S. patent application, Ser. No. 10/869,718, entitled "Schottky Barrier Rectifier and Method of Manufacturing the Same," filed Jun. 15, 2004, which is hereby incorporated by reference herein in its entirety.

This application is related to co-pending, commonly owned U.S. patent application, Ser. No. 11/320,313, entitled "Ultrafast Recovery Diode," filed Dec. 27, 2005, which is hereby incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Embodiments of the present invention relate to the field of rectifiers. More particularly, embodiments of the present invention relate generally to a fast recovery rectifier structure.

2. Related Art

An important factor in the efficiency of a switching power supply is the performance of the diodes used in such circuits. More particularly, the reverse recovery of such diodes can reduce turn-on loss of the transistor switch in such power supplies. For example, a reverse recovery current transient appears as an additional component of current during the turn-on of the switch, with the result that the turn-on loss of the switch is significantly higher that it would otherwise be without such reverse recovery component. Consequently, reducing diode reverse recovery charge (Qrr) is important for improving the efficiency of switching power supplies.

Unfortunately, however, if the reverse recovery is too abrupt, then the current and voltage will experience undesirable oscillations. Such oscillations can result in, for example, low efficiency power supply operation, a deleteriously noisy output (e.g., power supply ripple and/or electromagnetic interference), and/or extremely high and possibly damaging voltage spikes.

SUMMARY OF THE INVENTION

Thus, a fast recovery rectifier structure with reduced reverse recovery charge that maintains a soft recovery characteristic is highly desired. A further desire exists to meet the previously identified desire in a fast recovery rectifier structure that is formed using a trench for smaller geometries. Yet another desire exists to meet the previously identified desires in a manner that this compatible and complimentary with conventional semiconductor manufacturing processes and equipment.

Accordingly, various embodiments of the present invention disclose an apparatus and method for a fast recovery rectifier structure. Embodiments of the present invention are able to reduce the reverse recovery charge while maintaining a soft recovery characteristic. Also, embodiments of the present invention disclose a silicon based fast recovery rectifier structure involving the creation of Schottky diode regions in series with JFET channel regions, or a merged PiN Schottky (MPS) diode structure. The MPS diode structure enables

a higher Schottky to PiN ratio because of smaller geometries, and reduced channel resistance due to N doping between the well regions that reduce the contribution of hole injection during forward conduction, for example in one embodiment.

Specifically, the rectifier structure includes a substrate of a first dopant type. A first epitaxial layer lightly doped with said first dopant type is coupled to the substrate. A first metallization layer is coupled adjacent to the first epitaxial layer. A plurality of trenches is recessed into the first epitaxial layer, each of which is coupled to the metallization layer. The device also includes a plurality of wells each doped with a second dopant type, each of which is separated from one another, and wherein each of which is formed beneath and adjacent to a corresponding trench in the plurality of trenches. A plurality of oxide layers is formed on walls and a bottom of a corresponding trench such that a corresponding well is electrically isolated from the corresponding trench. A plurality of channel regions doped with said first dopant type is formed within the first epitaxial layer between two corresponding wells from the plurality of wells, and wherein each of the plurality of channel regions is more highly doped with the first dopant type than the first epitaxial layer.

Embodiments of the present invention also describe a method for forming fast recovery rectifier structures. The method includes depositing a second epitaxial layer doped with a first dopant type upon a substrate. The substrate is highly doped with the first dopant type. That is, the substrate is more highly doped than the second epitaxial layer. The method also deposits a first epitaxial layer lightly doped with the first dopant type on the second epitaxial layer. The second epitaxial layer is more highly doped than the first epitaxial layer. A plurality of trenches is etched into the first epitaxial layer. A plurality of oxide, gate definition spacers is formed on walls and bottoms of each of the plurality of trenches. A plurality of wells is implanted proximate a bottom of each of the plurality of trenches. Each of the plurality of wells is doped with a second dopant type, and is separated from one another. That is, each of the plurality of wells is electrically isolated from a corresponding trench. A first metallization layer is deposited upon the epitaxial layer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a side sectional view of an ultrafast recovery diode, in accordance with one embodiment of the present invention.

FIG. **2** is a cross section of an ultrafast recovery diode of FIG. **1** taken along a midplane of a p-well, in accordance with one embodiment of the present invention.

FIG. **3** is a top view of the ultrafast recovery diode, in accordance with one embodiment of the present invention.

FIG. **4** is a flow chart illustrating steps in a method for fabricating an ultrafast recovery diode with Schottky to PiN ratios more than one, in accordance with one embodiment of the present invention.

FIG. **5** is a chart illustrating exemplary current versus time recovery characteristics, in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to the preferred embodiments of the present invention, a fast recovery rectifier structure and a method for fabricating the structure, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the preferred embodiments, it will be understood that they are not